SECTION 10 - STRUCTURAL STEEL

(1996 Sixteenth Edition with 1997 - 2001 Interim Revisions)

Part A
General Requirements and Materials

10.1 APPLICATION

10.1.1 General

The specifications of this section are intended for design of steel components, splices and connections for straight beam and girder structures, frames, trusses, arches and metal structures, as applicable. For horizontally curved bridges, see the current AASHTO Guide Specifications for Horizontally Curved Bridges.

10.1.2 Notations

A = area of cross section (in.^{2}) (Articles 10.37.1.1, 10.34.4.7, 10.48.1.1, 10.48.4.2, 10.48.5.3 and 10.55.1)

A = bending moment coefficient (Article 10.50.1.1.2)

A_e = effective area of a flange or splice plate with holes (in.^{2}) (Articles 10.18.2.2.1, 10.18.2.2.3)

A_F = amplification factor (Articles 10.37.1.1 and 10.55.1)

A_f = sum of the area of the fillers on the top and bottom of the connected plate (in.^{2}) (Article 10.18.1.2)

$(AF_y)_{bf}$ = product of area and yield strength for bottom flange of steel section (lb) (Article 10.50.1.1.1)

$(AF_y)_c$ = product of area and yield strength of that part of reinforcing which lies in the compression zone of the slab (lb.) (Article 10.50.1.1.1)

$(AF_y)_{tf}$ = product of area and yield strength for top flange of steel section (lb.) (Article 10.50.1.1.1)

$(AF_y)_w$ = product of area and yield strength for web of steel section (lb.) (Article 10.50.1.1.1)

A_f = area of flange (in.^{2}) (Articles 10.39.4.4.2, 10.48.2.1, 10.53.1.2, and 10.56.3)

A_{fc} = area of compression flange (in.^{2}) (Article 10.48.4.1)

A_g = gross area of whole connected material (in.^{2}) (Article 10.19.4.2)

A_g = gross area of a flange or splice plate (in.^{2}) (Article 10.18.2.2.1 and 10.18.2.2)

A_n = net area of the fastener (in.^{2}) (Article 10.32.3.2.1 and 10.57.3.1)

A_p = smaller of either the connected plate area or the sum of the splice plate areas on the top and bottom of the connected plate (in.^{2}) (Article 10.18.1.2)

A_r^s = total area of longitudinal slab reinforcement steel for each beam over interior support (in.^{2}) (Article 10.38.5.1.3)

A_s = area of steel section (in.^{2}) (Articles 10.38.5.1.2, 10.54.1.1, and 10.54.2.1)

A_s^r = total area of longitudinal reinforcing steel at the interior support within the effective flange width (in.^{2}) (Article 10.38.5.1.2)

A_{tg} = gross area along the plane resisting tension (in.^{2}) (Article 10.19.4)

A_{tn} = net area along the plane resisting tension (in.^{2}) (Article 10.19.4)

A_{vg} = gross area along the plane resisting shear (in.^{2}) (Article 10.19.4)

A_{vn} = net area along the plane resisting shear (in.^{2}) (Article 10.19.4)

A_w = area of web of beam (in.^{2}) (Article 10.53.1.2)

a = distance from center of bolt under consideration to edge of plate (in.) (Articles 10.32.3.3.2 and 10.56.2)

a = spacing of transverse stiffeners (in.) (Article 10.39.4.4.2)

a = depth of stress block (in.) (Figure 10.50A)

B = constant based on the number of stress cycles (Article 10.38.5.1.1)

B = constant for stiffeners (Articles 10.34.4.7 and 10.48.5.3)

b = compression flange width (in.) (Tables 10.32.1A and 10.34.2A, Article 10.34.2.1.3)

b = distance from center of bolt under consideration to toe of fillet of connected part (in.) (Articles 10.32.3.3.2 and 10.56.2)

b = effective flange width (in.) (Articles 10.38.3, 10.38.5.1.2 and 10.50.1.1.1)

b = widest flange width (in.) (Article 10.15.2.1)

b = distance from edge of plate or edge of perforation to the point of support (in.) (Article 10.35.2.3)

b = unsupported distance between points of support (in.) (Table 10.35.2A and Article 10.35.2.3)

b = flange width between webs (in.) (Articles 10.37.3.1, 10.39.4.2, and 10.51.5.1)

b' = width of stiffeners (in.) (Articles 10.34.5.2, 10.34.6, 10.37.2.4, 10.39.4.5.1, and 10.55.2)

b' = width of a projecting flange element, angle, or stiffener (in.) Articles 10.34.2.2, 10.37.3.2, 10.39.4.5.1, 10.48.1, 10.48.2, 10.48.5.3, 10.50, 10.51.5.5, and 10.55.3)

b_{eb} = width of the body of the eyebar (in.) (Article 10.25.3)

C = web buckling coefficient (Articles 10.34.4, 10.48.5.3, and 10.48.8.)

C = compressive force in the slab (lb.) (Article 10.50.1.1.1)

C' = compressive force in top portion of steel section (lb.) (Article 10.50.1.1.1)

C_b = bending coefficient (Table 10.32.1A, Article 10.48.4.1)

C_c = column slenderness ratio dividing elastic and inelastic buckling (Table 10.32.1A)

C_{mx} = coefficient applied to bending term in interaction formula for prismatic members; dependent upon member curvature caused by applied moments about the X axis (Articles 10.36 and 10.54.2)

C_{my} = coefficient applied to bending term in interaction formula for prismatic members; dependent upon member curvature caused by applied moments about the Y axis (Articles 10.36 and 10.54.2)

c = buckling stress coefficient (Article 10.51.5.2)

D = clear distance between flanges (in.) (Article 10.15.2)

D = clear unsupported distance between flange components (in.) (Table 10.34.3A, 10.37.2A, 10.48.5A, 10.55.2A, Articles 10.18.2.3.4, 10.18.2.3.5, 10.18.2.3.7, 10.18.2.3.8, 10.18.2.3.9, 10.34.3, 10.34.4, 10.34.5, 10.37.2, 10.48.1, 10.48.2, 10.48.4, 10.48.5, 10.48.6, 10.48.8, 10.49.2, 10.49.3.2, 10.50.2.1, and 10.55.2)

D' = distance from the top of concrete slab to the neutral axis at which a composite section in positive bending theoretically reaches its plastic moment capacity when the maximum compressive strain in concrete slab is at 0.003 (Article 10.50.1.1.2)

D_c = clear distance between the neutral axis and the compression flange (in.) (Table 10.34.3A, Articles 10.48.2.1(b), 10.48.4.1, 10.49.2, 10.49.3.2.2 and 10.50)

D_{cp} = depth of web in compression at the plastic moment (in.) (Articles 10.50.1.1.2 and 10.50.2.1)

D_p = distance from top of the slab to the plastic neutral axis at the plastic moment (in.) (Article 10.50.1.1.2)

d = bolt diameter (in.) (Table 10.32.3B)

d = diameter of stud (in.) (Article 10.38.5.1)

d = depth of beam or girder (in.) (Article 10.13, Table 10.32.1A, Articles 10.48.2, 10.48.4.1, and 10.50.1.1.2)

d = diameter of rocker or roller (in.) (Article 10.32.4.2)

d_b = beam depth (in.) (Article 10.56.3)

d_c = column depth (in.) (Article 10.56.3)

d_o = spacing of intermediate stiffener (in.) (Articles 10.34.4, 10.34.5, 10.48.5.3, 10.48.6.3, and 10.48.8)

d_s = distance from the centerline of a plate longitudinal stiffener or the gage line of an angle longitudinal stiffener to the inner surface or the leg of the compression flange component (in.) (Table 10.34.3A, 10.34.5A, Articles 10.34.5 and 10.49.3.2)

E = modulus of elasticity of steel (psi) (Table 10.32.1A and Articles 10.15.3, 10.36, 10.37, 10.39.4.4.2, 10.54.1, 10.54.2 and 10.55.1)

E_c = modulus of elasticity of concrete (psi) (Article 10.38.5.1.2)

e = distance from the centerline of the splice to the centroid of the connection on the side of the joint under consideration (in.) (Articles 10.18.2.3.3, 10.18.2.3.5 and 10.18.2.3.7)

F_a = allowable axial stress (psi) (Table 10.32.1A and Articles 10.36, 10.37.1.2, and 10.55.1)

F_b = allowable bending stress (psi) (Table 10.32.1A and Articles 10.37.1.2 and 10.55.1)

F_{bc} = allowable compression flange stress specified in Table 10.32.1A (psi) (Article 10.18.2.3.8)

F_{bs} = allowable block shear rupture stress (psi) (Article 10.19.14)

F_{bt} = allowable tension flange stress specified in Table 10.32.1A (psi) (Article 10.18.2.3.8)

F_{bx} = allowable compressive bending stress about the X axis (psi) (Article 10.36)

F_{by} = allowable compressive bending stress about the Y axis (psi) (Article 10.36)

F_{cr} = critical stress of the compression flange plate or member (psi) (Articles 10.51.1, 10.51.5, 10.54.1.1, and 10.54.2.1)

F_{cu} = design stress for the flange at a point of splice (psi) (Article10.18.2.2.2)

F_D = maximum horizontal force (lb.) (Article 10.20.2.2)

F_e = Euler buckling stress (psi) (Articles 10.37.1, 10.54.2, and 10.55.1)

F'_e = Euler stress divided by a factor of safety (psi) (Article 10.36)

F_p = allowable bearing stress on high-strength bolts or connected material (psi) (Table 10.32.3B)

F_s = limiting bending stress (psi) (Article 10.34.4)

F_{sr} = allowable range of fatigue stress (psi) (Table 10.3.1A)

$F.S.$ = factor of safety (Table 10.32.1A and Articles 10.36 and 10.37.1.3)

F'_t = reduced allowable tensile stress on rivet or bolt due to the applied shear stress (psi) (Articles 10.32.3.3.4 and 10.56.1.3.3)

F_u = specified minimum tensile strength (psi) (Tables 10.2C, 10.32.1A and 10.32.3B, Articles 10.18.4 and 10.19.4)

F_u = tensile strength of electrode classification (psi) (Table 10.56A and Article 10.32.2)

F_{um} = maximum bending strength of either the top or bottom flange, whichever flange has the larger ratio of (f_s/F_{um}) (Article 10.48.8.2)

F_v = allowable shear stress (psi) (Tables 10.32.1A, 10.32.3B and 10.34.3A, and Articles 10.18.2.3.6, 10.32.2, 10.32.3, 10.34.4, 10.40.2.2)

F_v = shear strength of a fastener (psi) (Article 10.56.1.3)

F_w = design shear stress in the web at the point of splice defined in Article 10.18.2.3.6 (psi) (Articles 10.18.2.3.6, 10.18.2.3.7 and 10.18.2.3.9)

F_y = specified minimum yield strength of steel (psi) (Table 10.34.2A, 10.34.3A, 10.34.5A, 10.35.2A, 10.48.5A, and Articles 10.15.2.1, 10.15.3, 10.16.11, 10.19.4, 10.32.1, 10.32.4, 10.34, 10.35, 10.37.1.3, 10.38.5, 10.39.4, 10.40.2.2, 10.41.4.6, 10.46, 10.48, 10.49, 10.50, 10.51.5, and 10.54)

F_y^r = specified minimum yield strength of the reinforcing steel (psi) (Article 10.38.5.1.2)

F_{yf} = specified minimum yield strength of the flange (psi) (Articles 10.18.2.2.2, 10.18.2.3.4, 10.48.1.1, and 10.53.1)

F_{yw} = specified minimum yield strength of the web (psi) (Articles 10.18.2.3.4 and 10.53.1)

f = maximum induced stress in the bottom flange (psi) (Article 10.21.2)

f = maximum compressive stress (psi) (Article 10.41.4.6)

f_{DL} = non-composite dead-load stress in the compression flange (psi) (Articles 10.34.5.1 and 10.49.3.2)

f_{DL+LL} = total non-composite and composite dead load plus the composite live-load stress in compression flange at the most highly stressed section of the web (psi) (Articles 10.34.5.1 and 10.49.3.2)

f_a = calculated axial compression stress (psi) (Table 10.35.2A, 10.37.2A, 10.55.2A, and Articles 10.36 and 10.37)

f_b = calculated compressive bending stress (psi) (Table 10.34.2A, 10.34.3A, 10.37.2A, 10.55.2A, and Articles 10.37 and 10.39)

f_{bx} = calculated compressive bending stress about the x axis (psi) (Article 10.36)

f_{by} = calculated compressive bending stress about the y axis (psi) (Article 10.36)

f'_c = specified compressive strength of concrete as determined by cylinder tests at age of 28 days (psi) (Articles 10.38.1, 10.38.5.1.2, 10.45.3, and 10.50.1.1.1)

f_{dl1} = top flange compressive stress due to noncomposite dead load (psi) (Table 10.34.2A)

f_o = maximum flexural stress due to Group I loading divided by 1.3 at the mid-thickness of the flange under consideration for the smaller section at the point of splice (psi) (Articles 10.18.2.2.2 and 10.18.2.3.5)

f_{of} = flexural stress due to Group I loading divided by 1.3 at the mid-thickness of the other flange at the point of splice concurrent with f_o in the flange under consideration (psi) (Article 10.18.2.3.5)

f_r = range of stress due to live load plus impact, in the slab reinforcement over the support (psi) (Article 10.38.5.1.3)

f_s = maximum longitudinal bending stress in the flange of the panels on either side of the transverse stiffener (psi) (Article 10.39.4.4)

f_t = calculated tensile stress (psi) (Articles 10.32.3.3.3 and 10.56.1.3.3)

f_v = calculated shear stress (psi) (Table 10.34.3A, Articles 10.32.3.2.3 and 10.34.4.4)

g = gage between fasteners (in.) (Articles 10.16.14 and 10.24.5)

H = height of stud (in.) (Article 10.38.5.1.1)

H_w = horizontal design force resultant in the web at a point of splice (lb.) (Articles 10.18.2.3.8 and 10.18.2.3.9)

H_{wo} = overload horizontal design force resultant in the web at a point of splice (lb.) (Article 10.18.2.3.5)

H_{wu} = horizontal design force resultant in the web at a point of splice (lb.) (Articles 10.18.2.3.4 and 10.18.2.3.5)

h = average flange thickness of the channel flange (in.)(Article 10.38.5.1.2)

I = moment of inertia (in.^{4}) (Articles 10.34.4, 10.34.5, 10.38.5.1.1, 10.48.5.3, and 10.48.6.3)

I_s = moment of inertia of stiffener (in.^{4}) (Articles 10.37.2, 10.39.4.4.1, and 10.51.5.4)

I_t = moment of inertia of transverse stiffeners (in.^{4}) (Article 10.39.4.4.2)

I_y = moment of inertia of member about the vertical axis in the plane of the web (in.^{4}) (Article 10.48.4.1)

I_{yc} = moment of inertia of compression flange about the vertical axis in the plane of the web (in.^{4}) (Table 10.32.1A, Article 10.48.4.1)

J = required ratio of rigidity of one transverse stiffener to that of the web plate (Articles 10.34.4.7 and 10.48.5.3)

J = St. Venant torsional constant (in.^{4}) (Table 10.32.1A, Article 10.48.4.1)

K = effective length factor in plane of buckling (Table 10.32.1A and Articles 10.37, 10.54.1, 10.54.2 and Appendix C)

K_b = effective length factor in plane of buckling (Article 10.36)

K_h = hole size factor (Articles 10.32.3.2 and 10.57.3.1)

k = constant: 0.75 for rivets; 0.6 for high-strength bolts with thread excluded from shear plane (Article 10.32.3.3.4)

k = buckling coefficient (Table 10.34.3A, Articles 10.34.4, 10.39.4.3, 10.48.8, and 10.51.5.4)

k = distance from outer face of flange to toe of web fillet of member to be stiffened (in.) (Article 10.56.3)

k_1 = buckling coefficient (Article 10.39.4.4)

L = actual unbraced length (in.) (Table 10.32.1A and Articles 10.7.4, 10.15.3, and 10.55.1)

L = 1/2 of the length of the arch rib (in.) (Article 10.37.1)

L = distance between transverse beams (in.) (Article 10.41.4.6)

L_b = unbraced length (in.) (Table 10.48.2.1A and Articles 10.36, 10.48.1.1, 10.48.2.1, 10.48.4.1, and 10.53.1.3)

L_c = length of member between points of support (in.)(Article 10.54.1.1)

L_c = clear distance between the holes or between the hole and the edge of the material in the direction of the applied bearing force (in.) (Table 10.32.3B and Article 10.56.1.3.2)

L_p = limiting unbraced length for the yield moment capacity (in.) (Article 10.48.4.1)

L_r = limiting unbraced length for elastic lateral torsional buckling moment capacity (in.) (Article 10.48.4.1)

l = member length (in.) (Table 10.32.1A and Article 10.35.1)

M = maximum bending moment (lb-in.) (Articles 10.48.2, 10.48.8 and 10.54.2)

M_1 = smaller end moment at the end of a member (lb-in.) (Table 10.36A)

M_1 & M_2 = moments at two adjacent braced points (lb-in.) (Table 10.36A)

M_A = absolute value of moment at quarter point of the unbraced beam segment (lb-in.) (Table 32.1.A and Article 10.48.4.1)

M_B = absolute value of moment at midpoint of the unbraced beam segment (lb-in.) (Table 32.1.A and Article 10.48.4.1)

M_C = absolute value of moment at three-quarter point of the unbraced beam segment (lb-in.) (Table 32.1.A and Article 10.48.4.1)

M_c = column moment (lb-in.) (Article 10.56.3.2)

M_{cD} = moments caused by dead load acting on composite girder (lb-in.) (Article 10.50.1.2.2)

M_{max} = absolute value of maximum moment in the unbraced beam segment (lb-in.) (Table 32.1.A and Article 10.48.4.1)

M_p = full plastic moment of the section (lb-in.) (Articles 10.50.1.1.2 and 10.54.2.1)

M_r = lateral torsional buckling moment capacity (lb-in.) (Articles 10.48.4.1 and 10.53.1.3)

M_s = elastic pier moment for loading producing maximum positive moment in adjacent span (lb-in.) (Article 10.50.1.1.2)

M_{sD} = moments caused by dead load acting on steel girder (lb-in.) (Article 10.50.1.2.2)

M_u = design bending strength (lb-in.) (Articles 10.18.2.2.2, 10.48, 10.51.1, 10.53.1, and 10.54.2.1)

M_v = design moment due to the eccentricity of the design shear at a point of splice (lb-in.) (Articles 10.18.2.3.7 and 10.18.2.3.9)

M_{vo} = overload design moment due to the eccentricity of the design shear at a point of splice (lb-in.) (Article 10.18.2.3.5)

M_{vu} = design moment due to the eccentricity of the design shear at a point of splice (lb-in.) (Articles 10.18.2.3.3 and 10.18.2.3.5)

M_w = overload design moment at the point of splice representing the portion of the flexural moment assumed to be resisted by the web (lb-in.) (Articles 10.18.2.3.8 and 10.18.2.3.9)

M_{wo} = overload design moment at the point of splice representing the portion of the flexural moment assumed to be resisted by the web (lb-in.) (Article 10.18.2.3.5)

M_{wu} = design moment at a point of splice representing the portion of the flexural moment assumed to be resisted by the web (lb-in.) (Articles 10.18.2.3.4 and 10.18.2.3.5)

M_y = moment capacity at first yield (lb-in.) (Articles 10.18.2.2.2 and 10.50.1.1.2)

N_1 & N_2 = number of shear connectors (Article 10.38.5.1.2)

N_b = number of bolts in the joint (Articles 10.32.3.2.1 and 10.57.3.1)

N_c = number of additional connectors for each beam at point of contraflexure (Article 10.38.5.1.3)

N_s = number of slip planes in a slip critical connection (Articles 10.32.3.2.1 and 10.57.3.1)

N_w = number of roadway design lanes (Article 10.39.2)

n = ratio of modulus of elasticity of steel to that of concrete (Article 10.38.1)

n = number of longitudinal stiffeners (Articles 10.39.4.3, 10.39.4.4, and 10.51.5.4)

P = allowable compressive axial load on members (lb.) (Article 10.35.1)

P = axial compression on the member (lb.) (Articles 10.48.1.1, 10.48.2.1, and 10.54.2.1)

P, P_1, P_2 & P_3 = force in the slab or in the steel girder (lb.) (Article 10.38.5.1.2)

P_{cf} = design force for the flange at a point of splice (lb.) (Article10.18.2.2.3)

P_{cu} = design force for the flange at a point of splice (lb.) (Article10.18.2.2.2)

P_{fo} = overload design force for the flange at a point of splice (lb.) (Article10.18.2.2.2)

P_s = allowable slip resistance (lb.) (Article 10.32 2.2.1)

P_u = design axial compression strength (lb.) (Article 10.54.1.1)

p = allowable bearing (lb/in.) (Article 10.32.4.2)

Q = prying tension per bolt (lb.) (Articles 10.32.3.3.2 and 10.56.2)

Q = statical moment about the neutral axis (in.^{3}) (Article 10.38.5.1.1)

R = radius (ft.) (Article 10.15.2.1)

R = number of design lanes per box girder (Article 10.39.2.1)

R = reduction factor for hybrid girders (Articles 10.18.2.2.2, 10.18.2.2.4, 10.18.2.2.8, 10.40.2.1.1, 10.53.1.2, and 10.53.1.3)

R_b = bending capacity reduction factor (Articles 10.48.4.1, and 10.53.1.3)

Rev = a range of stress involving both tension and compression during a stress cycle (psi) (Table 10.3.1B)

R_s = design slip strength of a fastener (lb.) (Article 10.57.3.1)

R_s = vertical force at connections of vertical stiffeners to longitudinal stiffeners (lb.) (Article 10.39.4.4.8)

R_t = design tension strength of a fastener (lb.) (Article 10.56.1.3.3)

R_v = design shear strength of a fastener (lb.) (Article 10.56.1.3.2)

R_w = vertical web force (lb.) (Article 10.39.4.4.7)

r = radius of gyration (in.) (Articles 10.35.1, 10.37.1, 10.41.4.6, 10.48.6.3, 10.54.1.1, 10.54.2.1, and 10.55.1)

r_b = radius of gyration in plane of bending (in.) (Article 10.36)

r_y = radius of gyration with respect to the Y–Y axis (in.) (Article 10.48.1.1)

r' = radius of gyration of the compression flange about the axis in the plane of the web (in.) (Table 10.32.1A, and Article 10.48.4.1)

S = section modulus (in.^{3}) (Articles 10.48.2, 10.51.1, and 10.53.1.3)

S_r = range of horizontal shear (lb.) (Article 10.38.5.1.1)

S_s = section modulus of transverse stiffener (in.^{3}) (Articles 10.39.4.4 and 10.48.6.3)

S_t = section modulus of longitudinal or transverse stiffener (in.^{3}) (Article 10.48.6.3)

S_u = design shear strength of the shear connector (lb.) (Article 10.38.5.1.2)

S_{xc} = section modulus with respect to the compression flange (in.^{3}) (Table 10.32.1A, and Article 10.48.4.1)

S_{xt} = section modulus with respect to the tension flange (in.^{3}) (Article 10.53.1.2)

s = pitch of any two successive holes in the chain (in.) (Article 10.16.14.2)

T = range in tensile stress (psi) (Table 10.3.1B)

T = calculated direct tension per bolt (lb.) (Articles 10.32.3 and 10.56.2)

T = arch rib thrust at the quarter point from dead + live + impact loading (lb.) (Articles 10.37.1 and 10.55.1)

T_b = required minimum bolt tension stress (psi) (Articles 10.32.3.2 and 10.57.3.1)

T_{bs} = design block shear rupture strength (lb.) (Article 10.19.4)

t = thickness of the thinner outside plate or shape (in.) (Article 10.24.6)

t = thickness of members in compression (in.) (Table 10.35.2A and Article 10.35.2)

t = thickness of thinnest part connected (in.) (Articles 10.32.3.3.2 and 10.56.2)

t = thickness of the wearing surface (in.) (Article 10.41.2)

t = flange thickness (in.) (Articles 10.18.2.2.1, 10.34.2.1, 10.39.4.2, 10.48.1.1, 10.48.2.1, 10.50, and 10.51.5.1)

t = thickness of a flange angle (in.) (Article 10.34.2.2)

t = thickness of stiffener (in.) (Article 10.48.5.3)

t_b = thickness of flange delivering concentrated force (in.) (Article 10.56.3.2)

t_c = thickness of flange of member to be stiffened (in.) (Article 10.56.3.2)

t_f = thickness of the flange (in.) (Table 10.37.2A, 10.55.2A, and Articles 10.37.3, 10.55.3 and 10.39.4.3)

t_h = thickness of the concrete haunch above the beam or girder top flange (in.) (Article 10.50.1.1.2)

t_s = thickness of stiffener (in.) (Table 10.34.5A, 10.37.2A, 10.48.5A, 10.55.2A, and Article 10.34.5, 10.37.2, 10.48.5.3 and 10.55.2)

t_s = slab thickness (in.) (Articles 10.38.5.1.2, 10.50.1.1.1, and 10.50.1.1.2)

t_{tf} = thickness of top flange (in.) (Article 10.50.1.1.1)

t_w = web thickness (in.) (Table 10.34.3A, 10.48.5A, 10.55.2A, Articles 10.15.2.1, 10.18.2.3.4, 10.18.2.3.5, 10.18.2.3.7, 10.18.2.3.8, 10.18.2.3.9, 10.34.3, 10.34.4, 10.34.5, 10.37.2, 10.48, 10.49.2, 10.49.3, 10.55.2, and 10.56.3)

t' = thickness of outstanding stiffener element (in.) (Articles 10.39.4.5.1 and 10.51.5.5)

V = shearing force (lb.) (Articles 10.35.1, 10.48.5.3, 10.48.8, and 10.51.3)

V_o = maximum shear in the web due to Group I loading divided by 1.3 at the point of splice (lb.) (Article 10.18.2.3.5)

V_p = shear yielding strength of the web (lb.) (Articles 10.48.8 and 10.53.1.4)

V_r = range of shear due to live loads and impact (lb.) (Article 10.38.5.1.1)

V_u = design shear strength (lb.) (Articles 10.18.2.3.2, 10.48.5.3, 10.48.8, and 10.53.1.4)

V_v = calculated vertical shear (lb.) (Article 10.39.3.1)

V_w = design shear for a web (lb.) (Articles 10.39.3.1 and 10.51.3)

V_{wu} = design shear in the web at the point of splice (lb.) (Articles 10.18.2.3.2, 10.18.2.3.3 and 10.18.2.3.5)

W = length of a channel shear connector, (in.) (Article 10.38.5.1.2)

W_L = fraction of a wheel load (Article 10.39.2)

W_c = roadway width between curbs or barriers if curbs are not used (ft.) (Article 10.39.2.1)

W_n = least net width of the flange or splice plate (in.) (Article10.18.2.2.1)

w = length of a channel shear connector measured in a transverse direction on the flange of a girder (in.) (Article 10.38.5.1.1)

w = unit weight of concrete (pcf) (Article 10.38.5.1.2)

w = width of flange between longitudinal stiffeners (in.) (Articles 10.39.4.3, 10.39.4.4, and 10.51.5.4)

x = subscript, represents the x-x axis (Article 10.54.2)

y = subscript, represents the y-y axis (Article 10.54.2)

Y_o = distance from the neutral axis to the extreme outer fiber (in.) (Article 10.15.3)

$\bar{y}$ = location of steel sections from neutral axis (in.) (Article 10.50.1.1.1)

Z = plastic section modulus (in.^{3}) (Articles 10.48.1, 10.53.1.1, and 10.54.2.1)

Z_r = allowable range of horizontal shear on an individual connector (lb.) (Article 10.38.5.1)

α = constant based on the number of stress cycles (Article 10.38.5.1.1)

α = specified minimum yield strength of the web divided by the specified minimum yield strength of the tension flange (Articles 10.40.2, 10.40.4 and 10.53.1.2)

α = factor for flange splice design equal to 1.0 except that a lower value equal to (M_u/M_y) may be used for flanges in compression at sections where M_u is less than M_y (Article 10.18.2.2.2)

β = area of the web divided by the area of the tension flange (Articles 10.40.2 and 10.53.1.2)

β = factor applied to gross area of flange and splice plate in computing the effective area (Article 10.18.2.2.1)

θ = angle of inclination of the web plate to the vertical (Articles 10.39.3.1 and 10.51.3)

ψ = ratio of total cross sectional area to the cross sectional area of both flanges (Article 10.15.2)

ψ = distance from the outer edge of the tension flange to the neutral axis divided by the depth of the steel section (Articles 10.40.2 and 10.53.1.2)

Δ = amount of camber (in.) (Article 10.15.3)

Δ_{DL} = dead load camber at any point (in.) (Article 10.15.3)

Δ_m = maximum value of Δ_{DL} (in.) (Article 10.15.3)

ϕ = reduction factor (Articles 10.38.5.1.2, and Table 10.56A)

ϕ = longitudinal stiffener coefficient (Articles 10.39.4.3 and 10.51.5.4)

ϕ_{bs} = 0.8, reduction factor for block shear rupture strength (Article 10.19.4)

γ = ratio of A_f to A_p (Article 10.18.1.2)

μ = slip coefficient in a slip-critical joint (Articles 10.32.3.2 and 10.57.3)

10.1.3 Definition

The following terms are defined for general use in Section 10. Specialized definitions appear in individual Articles.

Allowable Design Strength – The capacity based on allowable stress in the case of SERVICE LOAD DESIGN METHOD, or the capacity based on design strength in the case of STRENGTH DESIGN METHOD.

Allowable Fatigue Stress Range – The maximum stress range that can be sustained without failure of the detail for a specified number of cycles.

Allowable Stress – The maximum stress permitted under full service load.

Anchor Rod - A fastener that is typically used to connect superstructure element to substructure and made from threaded rod or stud material.

Arch – A curved vertical structure in which the horizontal component of the force in the rib is resisted by a horizontal tie or its foundation.

Beam – A straight or curved horizontal structural member, primarily supporting transverse loads through flexure, shear and torsion actions. Generally, this term is used when the member is made of rolled shapes.

Beam-Column – A member subjected to a combination of axial force and bending moment.

Block Shear Rupture – Failure of a bolted web connection of coped beams or any tension connection when a portion of a plate tears out along the perimeter of the connecting bolts.

Bolt - A threaded fastener with a head, generally available in stock lengths up to about eight inches.

Bolt Assembly – The bolt, nut(s) and washer (s).

Bracing Member – A member intended to brace a main member, or part thereof, against lateral movement.

Charpy V-Notch Impact Requirement – The minimum energy required to be absorbed in a Charpy V-notch test conducted at a specified temperature.

Charpy V-notch Test – An impact test complying with the AASHTO T243M (ASTM A673M).

Clear Distance of Fasteners – The distance between edges of adjacent fastener holes.

Column – A vertical framed structural member primary supporting axial compression loads.

Collapse Load – That load which can be carried by a structural member or structure when failure is imminent.

Compact Section – A section which is capable of developing the fully plastic stress distribution in flexure. The rotational capacity required to comply with analysis assumptions used in various articles of this section is provided by satisfying various flange and web slenderness and bracing requirements.

Component – A constituent part of a structure or structural system.

Composite Beam/Girder – A beam/girder in which a steel beam/girder and concrete deck are interconnected by shear connectors and respond to force effects as a unit.

Cross Frame – Transverse truss framework connecting adjacent longitudinal flexural components.

Deck Truss – A truss system in which the roadway is at or above the elevation of the top chord of the truss.

Detail Category – A grouping of components and details having essentially the same fatigue resistance.

Diaphragm – A transverse flexural component connecting adjacent longitudinal flexural components.

Edge Distance of Fasteners – The distance perpendicular to the line of force between the center of a fastener hole and the edge of the component.

End Panel – The end section of a truss or girder.

Eyebar – A tension member with a rectangular section and enlarged ends for a pin connection.

Fastener – A rivet, bolt, threaded rod, or threaded stud that is used to fasten individual elements together.

Fatigue – The initiation and/or propagation of a crack due to repeated variation of normal stress with a tensile component.

Fatigue Design Life – The number of years that a detail is expected to resist the assumed traffic loads without fatigue cracking. In the development of these Specifications it has been taken as 75 years.

Fatigue Life – The number of repeated stress cycles that results in fatigue failure of a detail.

Finite Fatigue Life – The number of cycles to failure of a detail when the maximum probable stress range exceeds the constant amplitude fatigue threshold.

FCM – Fracture Critical Member – A tension member or a tension component of a flexural member (including those subject to reversal of stress) whose failure is expected to result in the collapse of the bridge

Fracture Toughness – A measure of a structural material or element to absorb energy without fracture, generally determined by the Charpy V-notch test.

Gage of Bolts – The distance between adjacent lines of bolts or the distance from the back of an angle or other shape to the first line of bolts.

Girder – A straight or curved structural horizontal member, primarily supporting transverse loads through flexure, shear and torsional actions. Generally, this term is used when the member is made of fabricated sections.

Grip – Distance between the nut and the bolt head.

Gusset Plate – Plate used to interconnect vertical, diagonal and horizontal truss members at a panel point.

Half-Through Truss Spans – A truss system with the roadway located somewhere between the top and bottom chords and which precludes the use of a top lateral system.

Horizontally Curved Beam/Girder – A beam/girder which is curved in plan.

Hybrid Girder – Fabricated steel girder with a web that has a specified minimum yield strength which is lower than one or both flanges.

Inelastic Action – A condition in which deformation is not fully recovered upon removal of the load that produces it.

Inelastic Redistribution – The redistribution of internal force effects in a component or structure caused by inelastic deformation at one or more sections.

Interior Panel – The interior section of a truss or girder component.

Lacing – Plates or bars to connect main components of a member.

Lateral Bracing Component – A component utilized individually or as part of a lateral bracing system to prevent lateral buckling of components and/or to resist lateral loads.

Load Path – A succession of components and joints through which a load is transmitted from its origin to its destination.

Longitudinally Loaded Weld – Weld with applied load parallel to the longitudinal axis of the weld.

Main Member – Any member on a critical path that carries bridge gravity load. The loss of capacity of these members would have serious consequences on the structural integrity.

Net Tensile Stress – The algebraic sum of two or more stresses in which the net effect is tension.

Non-Compact Section – A section that can develop the yield strength in compression elements before onset of local buckling, but cannot resist inelastic local buckling at strain levels required for a fully plastic stress distribution.

Orthotropic Deck – A deck made of steel plates stiffened with open or closed steel ribs welded to the underside.

Permanent Deflection – A type of inelastic deflection which remains in a component or system after the load is removed.

Pitch of Bolts – The distance along the line of force between the centers of adjacent holes.

Plate – A flat steel plate product whose thickness exceeds 0.25 in.

Portal Frames – End transverse truss bracing or Vierendeel bracing that provides for stability and resists wind or seismic loads.

Redistribution Moment – An internal moment caused by yielding in a continuous span bending component and held in equilibrium by external actions.

Redistribution of Moments – A process which results from formulation of inelastic deformation in continuous structures.

Redistribution Stress – The bending stress resulting from the redistribution moment.

Redundancy – The multiple load paths of a bridge which enables it to perform its design function in a damaged state.

Redundant Member – A member whose failure does not cause failure of the bridge.

Secondary Member - All members other than main member not designed to carry primary load.

Sheet – A flat rolled steel product whose thickness is between 0.006 in. and 0.25 in.

St. Venant Torsion – A torsional moment producing pure shear stresses on a cross-section in which plane sections remain plane.

Stress Range – The algebraic difference between extreme stresses resulting from the passage of a defined load.

Subpanel – A stiffened web panel divided by one or more longitudinal stiffeners.

Sway Bracing – Transverse vertical bracing between truss members.

Threaded Rod - An unheaded rod that is threaded its entire length, typically an “off-the-shelf” item.

Threaded Stud – An unheaded rod which is not threaded its entire length and typically threaded each end or one end.

Through Truss Spans – A truss system where the roadway is located near the bottom chord and which contains a top chord lateral system.

Tie Plates – Plates used to connect components of a member.

Transversely Loaded Weld – Weld with applied force perpendicular to the longitudinal axis of the weld.

Unbraced Length – Distance between brace points resisting the mode of buckling or distortion under consideration; generally, the distance between panel points or brace locations.

Warping Torsion – A twisting moment producing shear stress and normal stresses, and under which the cross-section does not remain plane.

Yield Strength – The stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain.

10.2 MATERIALS

10.2.1 General

These specifications recognize steels listed in the following subparagraphs. Other steels may be used; however, their properties, strengths, allowable stresses, and workability must be established and specified.

10.2.2 Structural Steels

Structural steels shall conform to the material designated in Table 10.2A. The modulus of elasticity of all grades of structural steel shall be assumed to be 29,000,000 psi and the coefficient of linear expansion 0.0000065 per degree Fahrenheit. The shear modulus of elasticity shall be assumed to be 11,200,000 psi.

10.2.3 Steels for Pins, Rollers, and Expansion Rockers

Steels for pins, rollers, and expansion rockers shall conform to one of the designations listed in Table 10.2A and 10.2B, or shall be stainless steel conforming to ASTM A 240 or ASTM A 276 HNS 21800.

10.2.4 Fasteners

Fasteners may be carbon steel bolts (ASTM A 307); power-driven rivets, AASHTO M 228 Grades 1 or 2 (ASTM A 502 Grades 1 or 2); or high-strength bolts, AASHTO M 164 (ASTM A 325), AASHTO M 253 (ASTM A 490) or fasteners conforming to ASTM A354 and ASTM A449. Structural fasteners shall conform the material designated in Table 10.2C.

In the Standard Specifications of California Department of Transportation, the following fastener descriptions are defined: “Bolt” is ASTM A307; “HS Bolt” is ASTM A325; “Threaded Rod” is ASTM A307 Grade C. “HS Threaded Rod” is ASTM A449. “Thread Stud” is ASTM A307 Grade C. “HS Threaded Stud” is ASTM A449; tensioning requirements only apply to A325 and A490 bolts; and “Bolt” is a generic term that applies to threaded rods, threaded studs, and anchor rods. The provisions and specifications in ASTM A325, A490, and A307 Grades A and B, are for headed bolts only and do not apply to threaded rods and studs. While ASTM A449 or A354 bolts seem to be the equal of ASTM A325 or A490 for certain diameters and grades, there are differences in the requirements for inspection and quality assurance, and heavy-hex head and nut dimensions. The tensioning requirements in the Standard Specifications only apply to ASTM A325 and A490 bolts.

10.2.5 Weld Metal

Weld metal shall conform to the current requirements of the *ANSI/AASHTO/AWS D1.5 Bridge Welding Code*.

TABLE 10.2A Minimum Material Properties – Structural Steel

AASHTO Designation[a,c]	M 270 Grade 36	M 270 Grade 50	M 270 Grade 50W		M 270 Grades 100/100W	
Equivalent ASTM Designation[c]	A 709 Grade 36	A 709 Grade 50	A 709 Grade 50W	A 709 Grade HPS 70W	A 709 Grades 100/100W[b]	
Thickness of Plates	Up to 4 in. incl.[e]	Up to 4 in. incl.	Up to 4 in. incl.	Up to 4 in. incl.	Up to $2^{1}/_{2}$ in. incl.	Over $2^{1}/_{2}$ in. to 4 in. incl.
Shapes[d]	All Groups[e]	All Groups	All Groups	Not Applicable	Not Applicable	Not Applicable
Minimum Tensile Strength, F_u, psi	58,000	65,000	70,000	90,000	110,000	100,000
Minimum Yield Strength, F_y, psi	36,000	50,000	50,000	70,000	100,000	90,000

[a] Except for the mandatory notch toughness and weldability requirements, the ASTM designations are similar to the AASHTO designations. Steels meeting the AASHTO requirements are prequalified for use in welded bridges.

[b] Quenched and tempered alloy steel structural shapes and seamless mechanical tubing meeting all mechanical and chemical requirements of A 709 Grades 100/100W, except that the specified maximum tensile strength may be 140,000 psi for structural shapes and 145,000 psi for seamless mechanical tubing, shall be considered as A 709 Grades 100/100W.

[c] M 270 Grade 36 and A 709 Grade 36 are equivalent to M 183 and A 36.
M 270 Grade 50 and A 709 Grade 50 are equivalent to M 223 Grade 50 and A 572 Grade 50.
M 270 Grade 50W and A 709 Grade 50W are equivalent to M 222 and A 588.
M 270 Grade 70W and A 709 Grade 70W are equivalent to A 852.
M 270 Grades 100/100W and A 709 Grades 100/100W are equivalent to M 244 and A 514.
ASTM A 709, Grade HPS 70W replaces AASHTO M 270, Grade 70W. The intent of this replacement is to encourage the use of HPS steel over conventional bridge steels due to its enhanced properties. AASHTO M 270, Grade 70W is still available, but should be used only with the owners approval.

[d] Groups 1 and 2 include all shapes except those in Groups 3, 4, and 5. Group 3 includes L-shapes over 3/4 inch in thickness. HP shapes over 102 pounds/foot, and the following W shapes:
Designations: W36 × 230 to 300 included
W33 × 200 to 240 included
W14 × 142 to 211 included
W12 × 120 to 190 included
Group 4 includes the following W shapes: W14 × 219 to 550 included
Group 5 includes the following W shapes: W14 × 605 to 730 included
For breakdown of Groups 1 and 2 see ASTM A 6.

[e] For nonstructural applications or bearing assembly components over 4 in. thick, use AASHTO M 270 Grade 36 (ASTM A 270 Grade 36).

TABLE 10.2B Minimum Material Properties – Pins, Rollers, and Rockers

Expansion rollers shall be not less than 4 inches in diameter			
AASHTO Designation with Size Limitations	M 102 to 20 in. in dia.	M 102 to 10 in. in dia.	M 102 to 20 in. in dia.
ASTM Designation Grade or Class	A 668 Class D	A 668 Class F	A 668[b] Class G
Minimum Yield Strength F_y, psi	37,500	50,000	50,000

[b] May substitute rolled material of the same properties.

TABLE 10.2C Minimum Material Properties – Fasteners

Type	ASTM Design	Availability			Strength	
		Material Type[a]	Grade	Diameter (in.)	Minimum Yield F_y (psi)	Minimum Tensile F_u (psi)
Unheaded Rod and Stud Material (only)	A36	C	-	to 8	36,000	58,000
	A572	HSLA	42	to 2	42,000	60,000
			50	to 6	50,000	65,000
	A588	HSLA ACR	-	to 4	50,000	70,000
				over 4 to 5	46,000	67,000
				over 5 to 8	42,000	63,000
	A307	C	C	-	36,000	58,000
Rivets	A502	C	1	-	NA	60,000[d]
		HSLA	2			80,000[d]
		HSLA, ACR	3			80,000[d]
Headed Bolt or Unheaded Rod Material	A354	A, QT	BD	$^1/_4$ to $2^1/_2$	130,000	150,000
				over $2^1/_2$ to 4	115,000	140,000
			BC	$^1/_4$ to $2^1/_2$	109,000	125,000
				over $2^1/_2$ to 4	99,000	115,000
	A449	C, QT	-	$^1/_4$ to 1 $1^1/_8$ to $1^1/_2$ $1^3/_4$ to 3	92,000 81,000 58,000	120,000 105,000 90,000
Headed Bolt Material (only)	A307	C	A, B	to 4	NA	60,000
	A325[b,c]	C, QT	-	$^1/_2$ to 1	92,000	120,000
				$1^1/_8$ to $1^1/_2$	81,000	105,000
	A490[b,c]	A, QT	-	$^1/_2$ to $1^1/_2$	130,000	150,000

[a] A = Alloy Steel
ACR = Atmospheric-Corrosion-Resistant Steel
C = Carbon Steel
HSLA = High-Strength Low-Alloy Steel
QT = Quenched and Tempered Steel

[b] Available with weathering (atmospheric corrosion resistance) characteristics comparable to ASTM A242 and A588 Steels.

[c] Threaded rod material with properties meeting ASTM A325,A490,and A449 specifications may be obtained with the use of an appropriate steel (such as ASTM A193,grade B7),quenched and tempered after fabrication.

[d] ASTM Specifications do not specify tensile strength for A502 rivets. A reasonable lower bound estimate F_u = 60,000 psi for Grade 1 and 80,000 for Grades 2 and 3 are a reasonable lower bound estimate (See Kulak, Fisher and Struik, Guide to Design for Bolted and Riveted Joints, Second Edition, John Wiley & Sons, 1987, New York, NY).

10.2.6 Cast Steel, Ductile Iron Castings, Malleable Castings and Cast Iron

10.2.6.1 Cast Steel and Ductile Iron

Cast steel shall conform to specifications for Steel Castings for Highway Bridges, AASHTO M 192 (ASTM A 486); Mild-to-Medium-Strength Carbon-Steel Castings for General Application, AASHTO M 103 (ASTM A 27); and Corrosion-Resistant Iron-Chromium, Iron-Chromium-Nickel and Nickel-Based Alloy Castings for General Application, AASHTO M 163 (ASTM A 743). Ductile iron castings shall conform to ASTM A 536.

10.2.6.2 Malleable Castings

Malleable castings shall conform to specifications for
+ Malleable Iron Castings, ASTM A 47, Grade 35018
+ (specified minimum yield strength 35,000 psi).

10.2.6.3 Cast Iron

Cast iron castings shall conform to specifications for Gray Iron Castings, AASHTO M 105, Class 30.

Part B
Design Details

10.3 REPETITIVE LOADING AND TOUGHNESS CONSIDERATIONS

10.3.1 Allowable Fatigue Stress Ranges

Members and fasteners subject to repeated variations or reversals of stress shall be designed so that the maximum stress does not exceed the basic allowable stresses given in Article 10.32 and that the actual range of stress does not exceed the allowable fatigue stress range given in Table 10.3.1A for the appropriate type and location of material given in Table 10.3.1B and shown in Figure 10.3.1C. For members with shear connectors provided throughout their entire length that also satisfy the provisions of Article 10.38.4.3, the range of stress may be computed using the composite section assuming the concrete deck to be fully effective for both positive and negative moment.

For unpainted weathering steel, A709, all grades, the values of allowable fatigue stress range, Table 10.3.1A, as modified by footnote d, are valid only when the design and details are in accordance with the FHWA *Technical Advisory on Uncoated Weathering Steel in Structures*, dated October 3, 1989.

TABLE 10.3.1A Allowable Fatigue Stress Range

Redundant Load Path Structures*				
Category (See Table 10.3.1B)	Allowable Range of Stress, F_{sr} (psi)[a]			
	For 100,000 Cycles	For 500,000 Cycles	For 2,000,000 Cycles	For over 2,000,000 Cycles
A	63,000 49,000[d]	37,000 29,000[d]	24,000 18,000[d]	24,000 16,000[d]
B	49,000	29,000	18,000	16,000
B′	39,000	23,000	14,500	12,000
C	35,500	21,000	13,000	10,000 12,000[b]
D	28,000	16,000	10,000	7,000
E	22,000	13,000	8,000	4,500
E′	16,000	9,200	5,800	2,600
F	15,000	12,000	9,000	8,000

Nonredundant Load Path Structures				
Category (See Table 10.3.1B)	Allowable Range of Stress, F_{sr} (psi)[a]			
	For 100,000 Cycles	For 500,000 Cycles	For 2,000,000 Cycles	For over 2,000,000 Cycles
A	50,000 39,000[d]	29,000 23,000[d]	24,000 16,000[d]	24,000 16,000[d]
B	39,000	23,000	16,000	16,000
B′	31,000	18,000	11,000	11,000
C	28,000	16,000	10,000 12,000[b]	9,000 11,000[b]
D	22,000	13,000	8,000	5,000
E[c]	17,000	10,000	6,000	2,300
E′	12,000	7,000	4,000	1,300
F	12,000	9,000	7,000	6,000

* Structure types with multi-load paths where a single fracture in a member cannot lead to the collapse. For example, a simply supported single span multi-beam bridge or a multi-element eye bar truss member has redundant load paths.

[a] The range of stress is defined as the algebraic difference between the maximum stress and the minimum stress. Tension stress is considered to have the opposite algebraic sign from compression stress.

[b] For transverse stiffener welds on girder webs or flanges.

[c] Partial length welded cover plates shall not be used on flanges more than 0.8 inches thick for nonredundant load path structures.

[d] For unpainted weathering steel, A 709, all grades, when used in conformance with the FHWA *Technical Advisory on Uncoated Weathering Steel in Structures*, dated October 3, 1989.

TABLE 10.3.1B

General Condition	Situation	Stress Kind of Stress	Illustrative Category (See Table 10.3.1A)	Example (See Figure 10.3.1C)
Plain Member	Base metal with rolled or cleaned surface. Flame cut edges with ANSI smoothness of 1,000 or less.	T or Rev [a]	A	1, 2
Built-Up Members	Base metal and weld metal in members of built-up plates or shapes (without attachments) connected by continuous full penetration groove weld (with backing bars removed) or by continuous fillet weld parallel to the direction of applied stress.	T or Rev	B	3, 4, 5, 7
	Base metal and weld metal in members of built-up plates or shapes (without attachments) connected by continuous full penetration groove welds with backing bars not removed, or by continuous partial penetration groove welds parallel to the direction of applied stress.	T or Rev	B′	3, 4, 5, 7
	Calculated flexural stress at the toe of transverse stiffener welds on girder webs or flanges.	T or Rev	C	6
	Base metal at ends of partial length welded coverplates with high-strength bolted slip-critical end connections. (See Note f.)	T or Rev	B	22
	Base metal at ends of partial length welded coverplates narrower than the flange having square or tapered ends, with or without welds across the ends, or wider than flange with welds across the ends:			
	(a) Flange thickness 0.8 inches	T or Rev	E	7
	(b) Flange thickness > 0.8 inches	T or Rev	E′	7
	Base metal at ends of partial length welded coverplates wider than the flange without welds across the ends.	T or Rev	E′	7
Groove Welded Connections	Base metal and weld metal in or adjacent to full penetration groove weld splices of rolled or welded sections having similar profiles when welds are ground flush with grinding in the direction of applied stress and weld soundness established by nondestructive inspection.	T or Rev	B	8, 10
	Base metal and weld metal in or adjacent to full penetration groove weld splices with 2 foot radius transitions in width, when welds are ground flush with grinding in the direction of applied stress and weld soundness established by nondestructive inspection.	T or Rev	B	13
	Base metal and weld metal in or adjacent to full penetration groove weld splices at transitions in width or thickness, with welds ground to provide slopes no steeper than 1 to $2^1/_2$, with grinding in direction of the applied stress, and weld soundness established by non-destructive inspection:			
	(a) AASHTO M 270 Grades 100/100W (ASTM A 709) base metal	T or Rev	B′	11
	(b) Other base metal	T or Rev	B	11

continue next page

TABLE 10.3.1B (continued)

General Condition	Situation	Kind of Stress	Stress Category (See Table 10.3.1A)	Illustrative Example (See Figure 10.3.1C)
Groove Welded Connections *(continued)*	Base metal and weld metal in or adjacent to full penetration groove weld splices, with or without transitions having slopes no greater than 1 to $2^{1}/_{2}$, when reinforcement is not removed and weld soundness is established by nondestructive inspection.	T or Rev	C	8, 10, 11
Groove Welded Attachments—Longitudinally Loaded [b]	Base metal adjacent to details attached by full or partial penetration groove welds when the detail length, *L*, in the direction of stress, is less than 2 in.	T or Rev	C	6
Fillet Welded Connections	Base metal at intermittent fillet welds.	T or Rev	E	—
	Shear stress on throat of fillet welds.	Shear	F	9
Fillet Welded Attachments—Longitudinally Loaded [b, c, e]	Base metal adjacent to details attached by fillet welds with length, *L*, in the direction of stress, less than 2 inches and stud-type shear connectors.	T or Rev	C	18,20
	Base metal adjacent to details attached by fillet welds with length, *L*, in the direction of stress greater than 12 times the plate thickness or greater than 4 inches:			
	(a) Detail thickness < 1.0 in.	T or Rev	E	7,9
	(b) Detail thickness 1.0 in.	T or Rev	E	7,9
Mechanically Fastened Connections	Base metal at gross section of high strength bolted slip resistant connections, except axially loaded joints which induce out-of-plane bending in connecting materials.	T or Rev	B	21
	Base metal at net section of high strength bolted bearing-type connections.	T or Rev	B	21
	Base metal at net section of riveted connections.	T or Rev	D	21
Eyebar or Pin Plates	Base metal at the net section of eyebar head, or pin plate	T	E	23,24
	Base metal in the shank of eyebars, or through the gross section of pin plates with:			
	(a) rolled or smoothly ground surfaces	T	A	23,24
	(b) flame-cut edges	T	B	23,24

See next page for footnotes

Footnotes for Table 10.3.1B

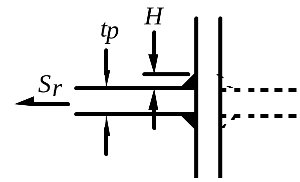
[a] “T” signifies ranges in tensile stress only, “Rev” signifies a range of stress involving both tension and compression during a stress cycle.

[b] “Longitudinally Loaded” signifies direction of applied stress is parallel to the longitudinal axis of the weld. “Transversely Loaded” signifies direction of applied stress is perpendicular to the longitudinal axis of the weld.

[c] Transversely loaded partial penetration groove welds are prohibited.

[d] Allowable fatigue stress range on throat of fillet welds transversely loaded is a function of effective throat and plate thickness. (See Frank and Fisher, Journal of the Structural Division, ASCE, Vol. 105, No. ST9, September 1979.)

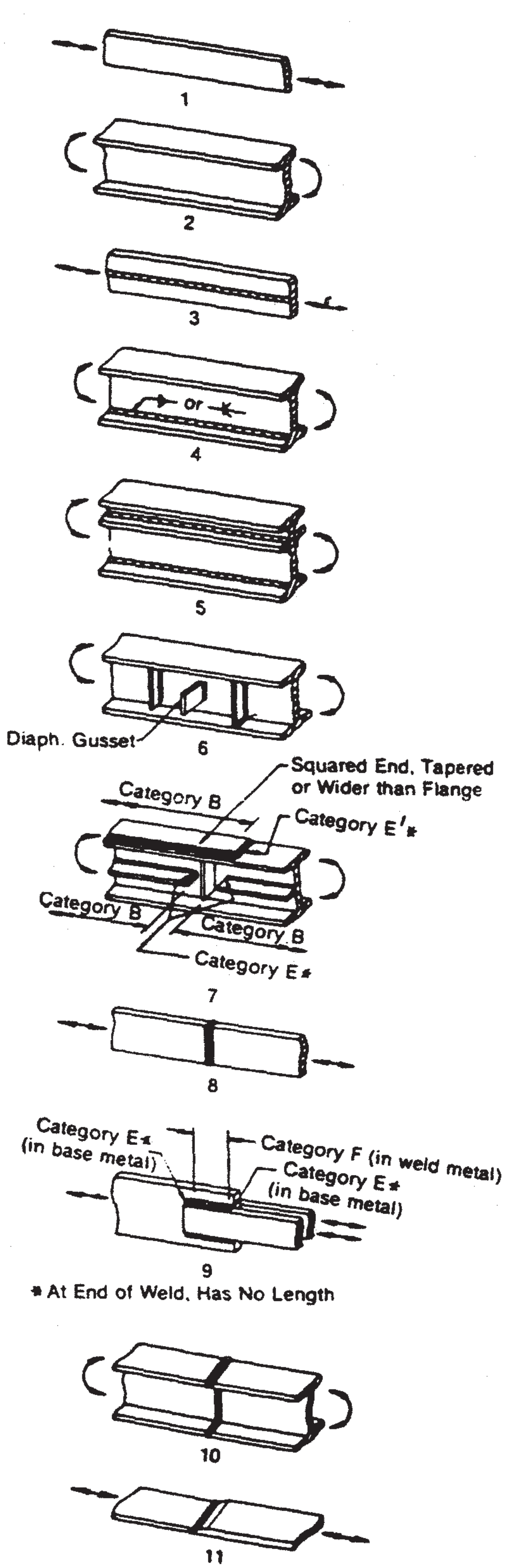
$$S_r = S_r^c \left(\frac{0.06 + 0.79H / t_p}{1.1 t_p^{\ 1/6}} \right)$$



where S_r^c is equal to the allowable stress range for Category C given in Table 10.3.1A. This assumes no penetration at the weld root.

[e] Gusset plates attached to girder flange surfaces with only transverse fillet welds are prohibited.

[f] See Wattar, Albrecht and Sahli, Journal of Structural Engineering, ASCE, Vol. III, No. 6, June 1985, pp. 1235-1249.



Note: Illustrative examples 12, 14 – 17 are deleted.

FIGURE 10.3.1C   Illustrative Examples

TABLE 10.3.2A Stress Cycle

Main (Longitudinal) Load Carrying Members					
Type of Road	Case	ADTT[a]	Truck Loading	Lane Loading[b]	Permit Loading
Freeways, Expressways, Major Highways, and Streets	I	2,500 or more	2,000,000[c]	500,000	100,000
Freeways, Expressways, Major Highways, and Streets	II	Less than 2,500	500,000	100,000	—
Other Highways and Streets not included in Case I or II	III	—	100,000	100,000	—

Transverse Members and Details Subjected to Wheel Loads						
Type of Road	Case	ADTT[a]	Longitudinal Span			
			≤ 40 Feet	> 40 Feet		
			Truck Loading	Truck Loading	Lane Loading	Permit Loading
Freeways, Expressways, Major Highways, and Streets	I	2,500 or more	Over 2,000,000	2,000,000	500,000	100,000
Freeways, Expressways, Major Highways, and Streets	II	Less than 2,500	Over 2,000,000	500,000	100,000	—
Other Highways and Streets	III	—	2,000,000	100,000	100,000	—

[a] Average Daily Truck Traffic (one direction).
[b] Longitudinal members should also be checked for truck loading.
[c] Members shall also be investigated for "over 2 million" stress cycles produced by placing a single truck on the bridge distributed to the girders as designated in Article 3.23.2.

Main load carrying components subjected to tensile force that may be considered nonredundant load path members—that is, where failure of a single element could cause collapse—shall be designed for the allowable stress ranges indicated in Table 10.3.1A for Nonredundant Load Path Structures. Examples of nonredundant load path members are flange and web plates in one or two girder bridges, main one-element truss members, hanger plates, and caps at single or two-column bents.

\+ See AASHTO "Guide Specifications for Fracture
\+ Critical Non-Redundant Steel Bridge Members."

10.3.2 Load Cycles

10.3.2.1 The number of cycles of maximum stress range to be considered in the design shall be selected from Table 10.3.2A unless traffic and loadometer surveys or other considerations indicate otherwise.

\+ For new structures and widenings, the number of
\+ stress cycles shall be based on Case I.

\+ **10.3.2.2** Allowable fatigue stress ranges shall apply to those Group Loadings that include live load or wind load.

10.3.2.3 The number of cycles of stress range to be considered for wind loads in combination with dead loads, except for structures where other considerations indicate a substantially different number of cycles, shall be 100,000 cycles.

10.3.3 Charpy V-Notch Impact Requirements

10.3.3.1 Main load carrying member components
\+ subjected to tensile force require supplemental impact properties.

10.3.3.2 These impact requirements vary depending on the type of steel, type of construction, welded or mechanically fastened, and the average minimum service temperature to which the structure may be subjected.*** Table 10.3.3A contains the temperature zone designations.

\+ The Standard Specifications of the California Depart-
\+ ment of Transportation, Section 55, lists the required
\+ minimum impact values for Zone 2.

*** The basis and philosophy used to develop these requirements are given in a paper entitled "The Development of AASHTO Fracture-Toughness requirements for Bridge Steels" by John M. Barsom, February 1975, available from the American Iron and Steel Institute, Washington, DC.

TABLE 10.3.3A Temperature Zone Designation for Charpy V-Notch Impact Requirements

Minimum Service Temperature	Temperature Zone Designation
0°F and above	1
–1°F to –30°F	2
–31°F to –60°F	3

10.3.3.3 Components requiring mandatory impact properties shall be designated on the drawings and the appropriate Charpy V-notch impact values shall be +
designated in the contract documents.

10.3.3.4 M 270 Grades 100/100W steel shall be supplied to Zone 2 requirements as a minimum.

10.3.4 Shear

When longitudinal beam or girder members in + bridges designed for Case 1 roadways are investigated for "over 2 million" stress cycles produced by placing a single truck on the bridge (see footnote (c) of Table 10.3.2A), the total shear force in the beam or girder under this single-truck loading shall be limited to 0.58 F_yDt_wC. The constant C, the ratio of the buckling shear stress to the shear yield stress is defined in Article 10.34.4.2 or Article 10.48.8.1.

10.3.5 Loading +

The fatigue loading shall be at service load and shall +
include permit loading. The load combination for permit +
loading shall be a P load with a β = 1.15 and an associated +
HS loading. The load shall be calculated according to +
footnote (f) in Table 3.23.1.

10.4 EFFECTIVE LENGTH OF SPAN

For the calculation of stresses, span lengths shall be assumed as the distance between centers of bearings or other points of support.

10.5 DEPTH RATIOS

10.5.1 For noncomposite beams or girders, the ratio + of the depth of girder to the length of span preferably should not be less than 0.04. +